BIOLOGY

Free Radicals Power Life

Free radicals, which contain unpaired electrons, have been found associated with life processes by a team of Washington University scientists.

➤ A MOLECULAR BRIDGE between the extremely speedy chemical steps that power plant and animal life has been discovered in the unusual molecules known as free radicals.

Still poorly understood by scientists, the free radicals are shown by Washington University scientists to:

1. Spark the unique reactions with which green plants store the sun's energy.

2. Act in the biochemical processes which release from food the energy required for life activities.

Discovery of the vital role of free radicals in normal life processes is expected to provide new attack methods on unsolved problems in biology and medicine. The damaging effects of atomic and other radiation and of some cancer-producing chemicals are believed to be due to the formation of free radicals in affected cells.

The Washington University demonstration of free radicals in normal cell processes, such as respiration and photosynthesis, will stimulate new efforts at understanding disease processes.

The team of scientists was directed by Dr. Barry Commoner, professor of botany, in collaboration with Drs. Richard E. Norberg, associate professor of physics, and Jonathan Townsend, assistant professor of physics. Working with Dr. Commoner were Dr. Janet V. Passonneau, research associate in botany, Mrs. Barbara Sue Lippincott, graduate student in zoology, and John J. Heise, graduate student in botany.

Possible existence of free radicals in living cells was suggested, on theoretical grounds, about 25 years ago.

Demonstration at Washington University that these elusive substances are active in living things was the culmination of seven years' work. This was based on new knowledge in electron physics resulting from the discovery in 1945 by a Russian scientist, E. Zavoisky, of the electron's absorption, of radiofrequency energy.

As a result, a new instrument came into use, the electron spin resonance spectrometer, which employs radio energy in the presence of a strong electromagnet to reveal the presence of the unpaired electrons. Free radicals are known to contain unpaired electrons and are therefore capable of exerting a magnetic effect in the spectrometer.

In ordinary molecules all electrons are paired in a way that cancels their magnetism so they are not detected by the spectrometer.

The results on biological free radicals were obtained with a new type of electron spin spectrometer, which can detect the extremely small amount of free radical anticipated. It was designed and constructed by Dr. Townsend.

The biologists extracted from pig heart muscle an enzyme that catalyzes the burning of food. This enzyme, and the chemical substances on which it acts, were placed in a glass tube inserted in the spectrometer. Recent experiments showed that a few minutes after the enzyme begins to act, free radicals appear, then disappear as the reaction comes to completion.

The spectrometer is so sensitive that in this experiment about one-billionth of an ounce of free radical was detected.

This result proves that enzymes removed from living cells form free radicals as they exert their catalytic effects. It confirms a theory first proposed in 1930 by the late Dr. Leonor Michaelis, biochemist at the Rockefeller Institute for Medical Research, New York.

During the summer of 1956 the investigators ground up spinach leaves in sugar solution to obtain from the broken spinach cells the green particles called chloroplasts that contain most of the active agents of photosynthesis. These preparations were found to contain a surprising amount of free radical.

A strong light was arranged to illuminate the glass cell containing the chloroplasts in the spectrometer. When the light is turned on, the spectrometer shows a sudden jump in free radical content.

Detailed measurements recently analyzed by Dr. Norberg show that the chloroplasts contain two types of substances with unpaired electrons.

One of these is a complex of the green substance of plants, chlorophyll, with protein. When this complex is illuminated, the absorbed light releases unpaired electrons. These quickly disappear when the light is turned off.

If the light is kept on, the unpaired electrons generated in the chlorophyll are passed on to a second free radical, which in turn gives up the electron to enzymes that carry out the photosynthetic chemistry. Thus the investigators demonstrated for the first time the occurrence of a free radical chain reaction in photosynthesis.

This result agrees with predictions in 1941 made by Dr. Albert Szent-Gyorgyi, Nobel Laureate in medicine in 1937, that photosynthesis is a result of the flow of unpaired electrons in the chloroplast.

The Washington University team reported the first evidence of unpaired electrons in illuminated chloroplasts last October.

Living cells of the microscopic plant, *Chlorella*, were examined in the electron spin resonance spectrometer. The instrument showed the presence of a free radical apparently identical with the free radical found last summer in the spinach chloroplasts.

When the light is turned on, the amount of this free radical in living *Chlorella* cells increases abruptly. When the cells are again darkened, the amount decreases. This represents the first proof that free radicals are formed in the activity of a living cell.

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PHYSICS

Better Switches Needed

➤ EASIER WAYS to build big computing machines by the use of better switching networks was the topic of an international symposium on the theory of switching held at the Computation Laboratory of Harvard University.

Wiring plans using switches with doorbells, house electric lights and telephone central offices are all examples of electrical switching networks. More advanced switching networks will be needed for the coming machines for translating languages, automation in factories and large-scale data processing machines in business offices.

Wiring switches to do a particular job is a tricky problem. Modern switching networks do not stop with the use of ordinary switches. They use electric relays, vacuum tubes, transistors, magnetic core devices, germanium diodes and many other elements. Even the experts admitted that wiring the best network for a job is hard.

Many different strategies for figuring out how to use switches were discussed. Various kinds of diagrams and advanced mathematical methods, such as lattice and matrix algebra and logical techniques, were presented.

Using computers to figure out how to use switches to build new and better computing machines is one technique under investigation both here and abroad. Photographs of a Russian switch network computer were shown.

In the 40 papers presented at the symposium, the consensus was that although the understanding of switching theory has advanced greatly in the past few years, no one has yet discovered a really easy way to do this kind of design.

Nine foreign countries, besides the United States, were represented by the speakers at the meeting. Papers of high quality were sent by Russian and Czechoslovakian experts who, at the last minute, cabled that they were unable to come.

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